Actuarial Society of India

EXAMINATIONS

17th November 2005

Subject CT5 – General Insurance, Health and Life Contingencies

Time allowed: Three Hours (10.30 – 13.30 pm)

Total Marks : 100

INSTRUCTIONS TO THE CANDIDATES

1.   Do not write your name anywhere on the answer scripts. You have only to write your Candidate's Number on each answer script.

2.   Mark allocations are shown in brackets.

3.   Attempt all questions, beginning your answer to each question on a separate sheet. However, answers to objective type questions could be written on the same sheet.

4.   Fasten your answer sheets together in numerical order of questions. This, you may complete immediately after expiry of the examination time.

5.   In addition to this paper you should have available graph paper, Actuarial Tables and an electronic calculator.

AT THE END OF THE EXAMINATION

Hand in both your answer scripts and this question paper to the supervisor.

Q.1   A select table (select period 5 years) is based on the following rates of mortality:

$$q_{[x]+t} = \frac{0.02}{1.02} \quad \text{(for all values of x and values of t<5)}$$

$$q_x = \frac{0.03}{1.03} \quad \text{(for al values of x)}$$

If $l_{[10]} = 100{,}000$, calculate

a) l_{45} **(2)**
b) $l_{[40]+1}$ **(1)**
                                                                                                                           Total [3]

Q.2 The force of mortality at age x in a special mortality table μ'_x, is related to the corresponding force of mortality in a standard mortality table μ_x, by the relationship:

$$\mu'_{x+t} = \mu_{x+t} + k \qquad t>0$$

where k is a constant which does not depend on t.

a) Show that
$$_tp'_x = {_tp_x} \exp\{-kt\} \qquad t>0 \tag{3}$$

b) Hence or otherwise show that the expected present value of an immediate temporary annuity due of 1 per annum issued to a life aged x with a term of n years valued using the special mortality table and a valuation rate of i per annum is given by:

$$\ddot{a}_{x:\overline{n}|}$$

where this function is calculated using the standard mortality table and a valuation rate of interest j per annum given by:
$$j = (1+i) \exp\{k\} - 1 \tag{3}$$
                                                                                                                           Total [6]

Q.3 Describe the four different methods of allocating bonuses to with-profits contacts and how they differ in terms of rate of distribution of surplus.

                                                                                                                                   [4]

Q.4 Use a general reasoning argument to construct Thiele's differential equation for a regular premium n-year term assurance issued to a life aged x by considering the change in reserves over a short time period. Assume that:
-    interest is earned continuously at force of interest δ;
-    premiums are payable continuously at rate $\overline{P}_{x:\overline{n}|}^{1}$ per annum; and
-    the Sum Assured of 1 is payable immediately on death

                                                                                                                                   [5]

Q.5 What are the advantages and disadvantages of using a single figure index to measure mortality.

[6]

Q.6 A special deferred annuity product provides the following benefits for a life aged 45 years.

- on survival to age 65, an annuity of Rs.5,000 p.a. weekly in advance for 5 years certain and for life thereafter
- on death before age 55, Rs.10,000 payable immediately on death
- on death between ages 55 and 65, Rs.25,000 payable immediately on death

Annual premiums are payable in advance until age 65 or earlier death.

Determine the level annual premium payable.

Basis: Mortality: AM92 Ultimate Mortality table before age 65
                      PMA92C20 Ultimate Mortality after age 65
       Interest: 4% p.a. throughout

Ignore expenses.   **[6]**

Q.7 A life insurance company uses the three-state illness-death model as shown below to calculate premiums for a 2-year sickness policy issued to healthy policyholders aged 60.

A life office uses the following 3 state model to calculate single premium for a 3 year sickness policy issued to healthy policy holders aged 60 at inception The policy provides a benefit of Rs50,000 at the end of each year if the policyholder is then sick, and a benefit of Rs 2,00,000 at the end of the year of death.
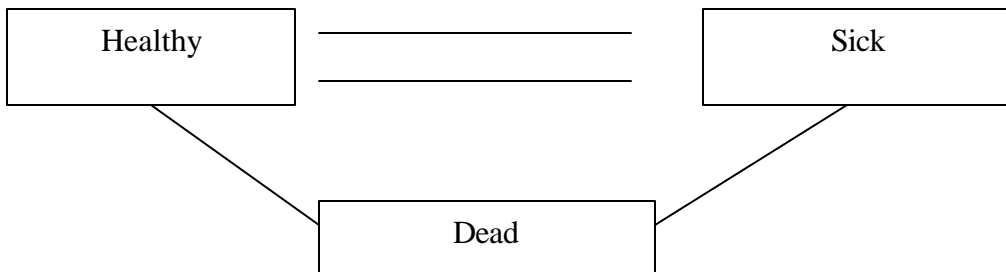
Let S_t represent the state occupied by the policyholder at age 60+t so that S_o=H & for t=1,2,3, S_t=H, S or D

The transition probabilities used by the life office are defined in the following way:

$$P_{60+t}^{ij} = \{Pr(S_{t+1}=j)\big| S_t=i\}$$

For t=0, 1,2 assume that

$$P_{60+t}^{HH} = \quad 0.92 \qquad\qquad P_{60+t}^{HS} = \qquad 0.08$$

$$P_{60+t}^{SH} = \quad 0.7 \qquad\qquad P_{60+t}^{SS} = \qquad 0.25$$

Determine the single premium payable under the policy assuming an interest rate of 5% pa. Ignore expenses.

[7]

Q.8 A multiple decrement table that allows for age retirements and deaths between the ages of 61 and 63 is as follows:

Age	$(al)x$	$(ad)_x^r$	$ad)_x^d$
61	10,000	1,291	494
62	8,215	1,471	662
63	6082		

Following improvements in the mortality experience, it is decided to construct a new table with the independent rates of mortality reduced by 40%.

Construct the new multiple decrement table. **[9]**

Q.9 Obtain a simplified expression for an annuity due of Rs.30,000 payable annually during the joint lifetime and the lifetime of the survivor of (40) and (50) and subject to the provision that it will continue for at least 20 years after the first death and 10 years after the second death.

[10]

Q.10 A life insurance company sells 4-year decreasing term assurance policies, with level premiums payable annually in advance for the term of the policy, but ceasing on earlier death. The initial Sum assured is Rs.200,000 decreasing by Rs.50,000 at each policy anniversary and the death benefit is payable at the end of year of death.

The company allows for the following when calculating premiums

Initial Expenses: Rs.300 plus 25% of the annual premium

Renewal Expenses: Rs.30 per annum plus 2.5% of annual premium, incurred at the time of payment of second and subsequent premiums

Mortality: AM92 select
Interest: 4% per annum (for all rates needed)

For a male aged exactly 60 years at outset:

i)   Write down the gross future loss random variable at the outset of the policy.   **(3)**

ii)   Calculate the office premium using a discounted cashflow projection, assuming no
withdrawals, ignoring reserves.   **(6)**

iii) Without further calculation explain the effect of
   a.   Allowing for the setting up of reserves in the calculation in part ii)
   b.   Having set up reserves in iii)a., increasing the discount rate to 10% p.a.

(3)
Total   [12]

Q.11 An employer provides the following benefits for his employees:

- immediately on death in service, a lump sum of Rs 2,00,000

- immediately on withdrawal from service (other than on death or in ill health), a lump sum
  equal to Rs5,000 for each completed year of service

- immediately on leaving due to ill health, a benefit of Rs 50,000 *pa* payable monthly in advance
  for 5 years certain and then ceasing, and,

- on survival in service to age 65, a pension of Rs 20,000 pa for each complete year of service,
  payable monthly in advance from age 65 for 10 years certain and life thereafter.

Calculate the expected present value of each of the above benefits for a new entrant aged exactly 62,
using the following basis:

Interest: 6% pa to retirement, 4% pa thereafter

Mortality after retirement: PMA92C20

Independent rates of decrement while in service:

Age x	q^d	q^w	q^i
62	0.018	0.1	0.020
63	0.02	0.15	0.015
64	0.023	0.2	0.010

where d represents death, i ill health retirement and w withdrawal.

Total [15]

Q.12 A life office issues a three-year unit-linked endowment policy to a male life aged exactly 50. A premium of Rs20,000 is payable at the start of each year. The allocation proportion is 90% in Year 1 and 97% in year 2 and 99% in year 3. At the end of the year of death during the term, the policy pays the higher of Rs 50,000 and the bid value of units allocated to the policy after deduction of the fund management charge.

In addition, a bonus of 5% of the (bid) value of the unit fund is payable at maturity. The life office makes the following assumptions in projecting future cash flows:

Mortality AM92 Ultimate

Initial expenses: Rs1000 incurred at outset in year 1
Renewal expenses: Rs500 incurred at the start of years 2 and 3
Fund management charge: 2.5% *pa*, taken at the end of each year prior to payment of any benefits

Non-unit fund interest rate: 4% *pa*

Bid/offer spread: 2.5%

Unit fund growth rate: 8% *pa*

Create tables to show the following:
(i) the growth of the unit fund   **(5)**
(ii) the profit signature, assuming no non-unit provisions are held   **(6)**
(iii) the profit signature after taking into account non-unit provisions. The amount of
the non-unit provisions to be held at the start of each year is to be equal to 3% of
the unit fund value immediately prior to payment of the premium then due.   **(6)**
                                                                                                                         Total [17]

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